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(54) **CONTAINERIZED INFRASTRUCTURE FOR DEPLOYMENT OF MICROSERVICES**

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G06F 9/44	(2018.01)
G06F 8/60	(2018.01)

(52) **U.S. Cl.**
CPC ***G06F 8/60*** (2013.01)

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See application file for complete search history.

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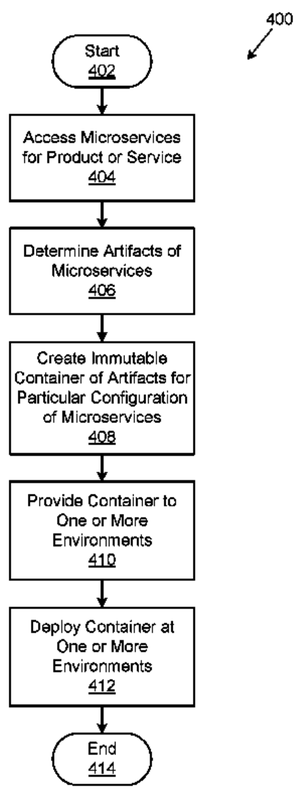
(57) **ABSTRACT**

A method, system and computer-usable medium for containerized deployment of microservices used to deploy a product or service, such as a software application running on an information handling system is described. Artifacts related to particular versions of the one or more microservices are determined. An immutable container of the artifacts is created and provided to one more environments using the same configuration of the product or service. The container is deployed in the environments during release of the product or service.

17 Claims, 4 Drawing Sheets



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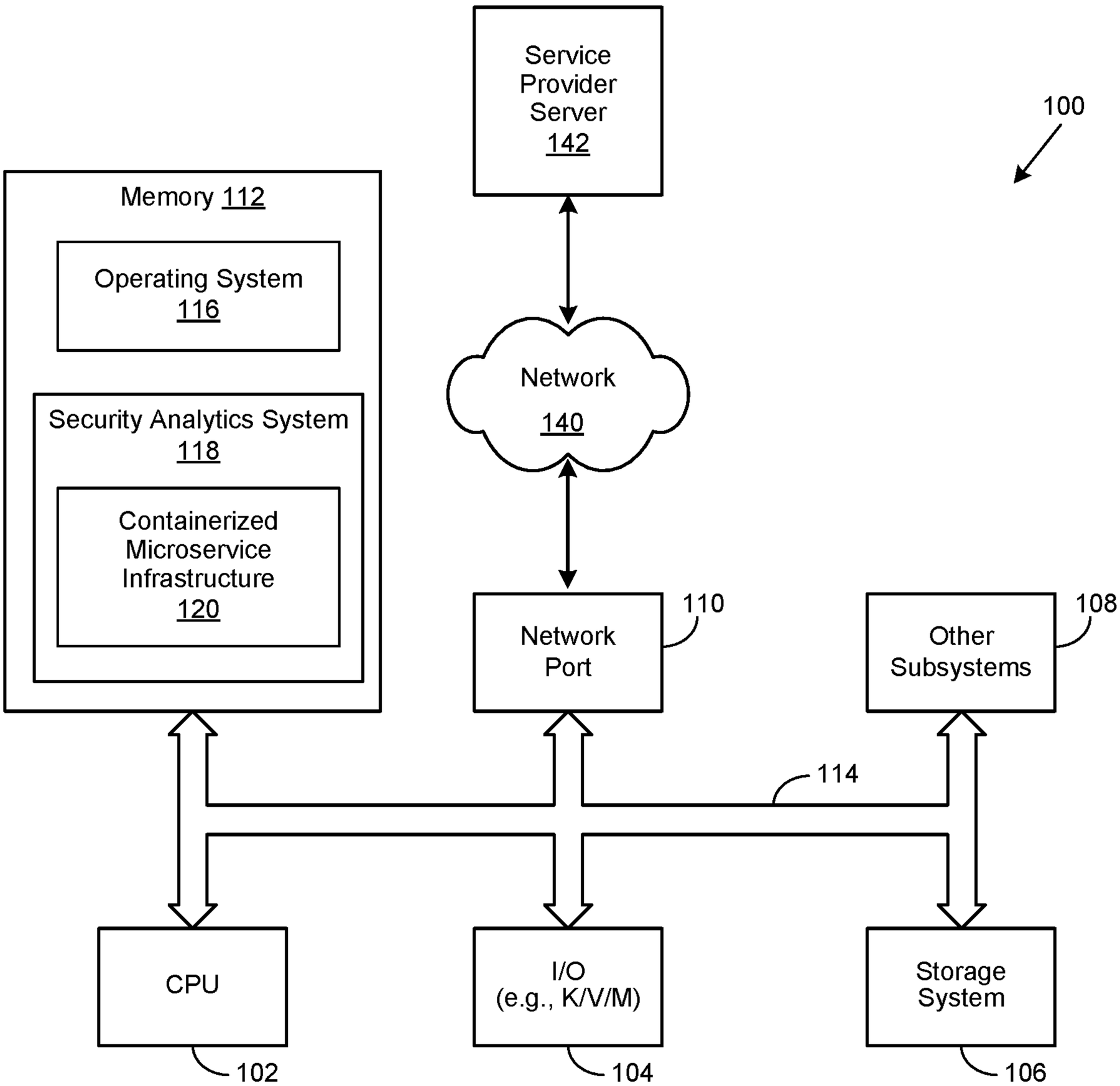
Service Provider Server 142
100
Memory 112
Operating System 116
Security Analytics System 118
Containerized Microservice Infrastructure 120
Network 140
Network Port
110
Other Subsystems
108
114
CPU
I/O (e.g., K/V/M)
Storage System
102
104
106

FIGURE 1

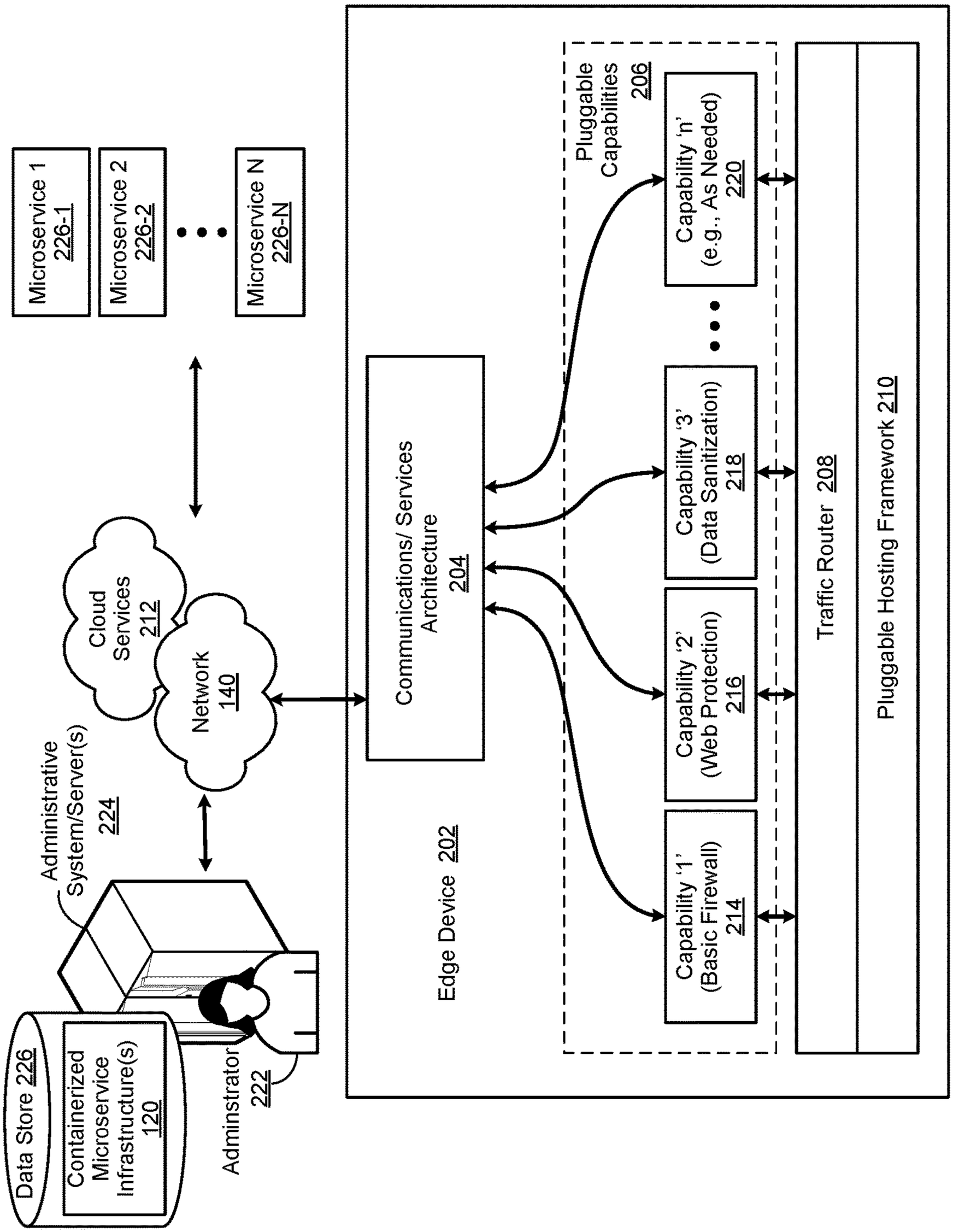
Microservice 1 226-1
Microservice 2 226-2
Microservice N 226-N
Edge Device 202
Pluggable Capabilities 206
Capability 'n' (e.g., As Needed) 220
Capability '3' (Data Sanitization) 218
Capability '2' (Web Protection) 216
Capability '1' (Basic Firewall) 214
Communications/ Services Architecture 204
Traffic Router 208
Pluggable Hosting Framework 210
Cloud Services 212
Network 140
Administrative System/Server(s) 224
Data Store 226
Containerized Microservice Infrastructure(s) 120
Adminstrator 222

FIGURE 2

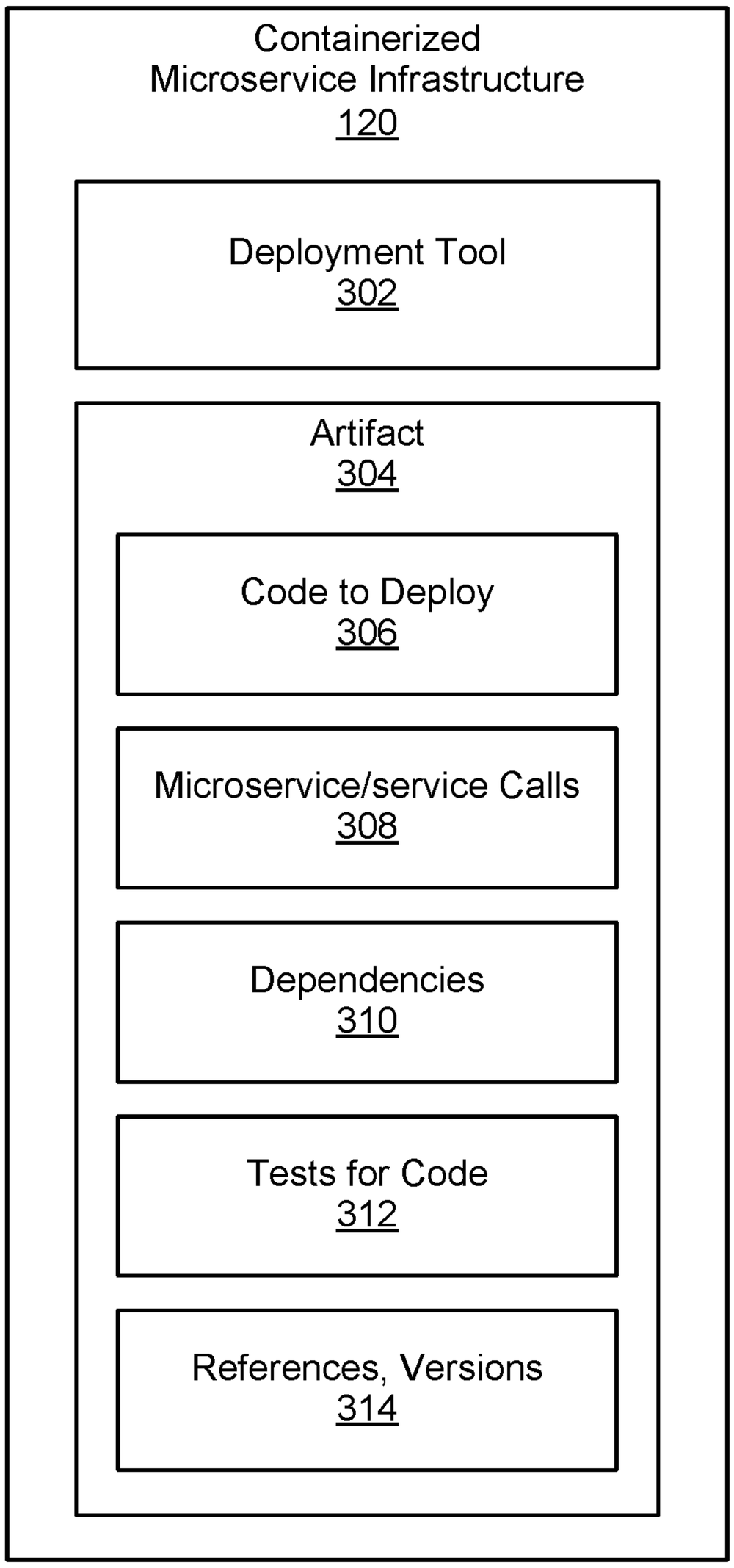
Containerized
Microservice Infrastructure
120
Deployment Tool
302
Artifact
304
Code to Deploy
306
Microservice/service Calls
308
Dependencies
310
Tests for Code
312
References, Versions
314

FIGURE 3

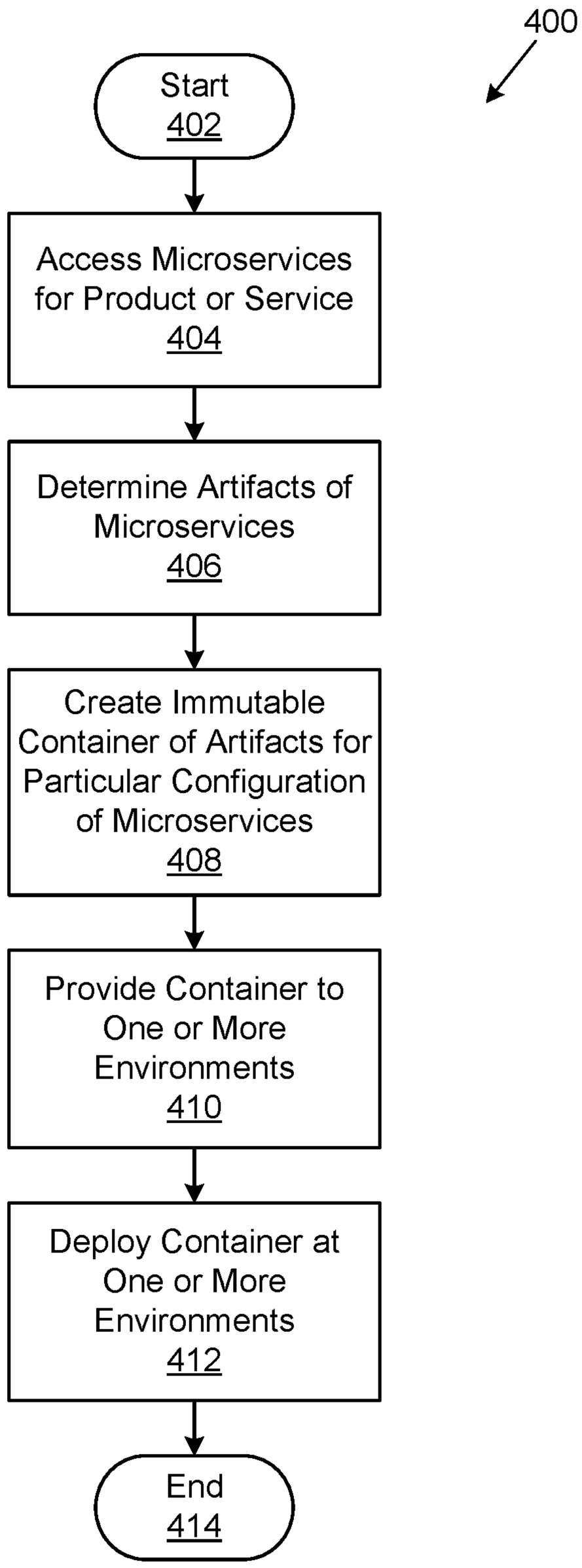
400
Start
402
Access Microservices for Product or Service
404
Determine Artifacts of Microservices
406
Create Immutable Container of Artifacts for Particular Configuration of Microservices
408
Provide Container to One or More Environments
410
Deploy Container at One or More Environments
412
End
414

FIGURE 4

CONTAINERIZED INFRASTRUCTURE FOR DEPLOYMENT OF MICROSERVICES

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates in general to the field of computers and similar technologies, and in particular to software utilized in this field. Still more particularly, the present invention relates to a method, system and computer-usable medium for containerized deployment of microservices.

Description of the Related Art

In providing for products or services, such as software applications, which run on information handling systems or computing systems, different microservices may be used. Microservices typically use multiple external dependencies, such as libraries and tools, that can change over time, making it difficult to repeatably and consistently deploy the use of the same versions. In addition, versions of microservices, can change over time, which can affect replication or duplication for future releases and deployments.

To assure consistent configurations throughout various stages of the product or service, it is imperative that the same configuration using the same versions of software code or microservice be implemented. This assures proper deployment throughout the various stages, including accurately debugging configurations implemented on different environments.

Assuring correct versions can become more problematic, when such software code or microservices, are not in the control of a developer(s) implementing and providing the services or products that are run on the information handling systems or computing systems.

In certain cases, microservices can have various external dependencies, such as libraries and tools, which have version pinning models used to reference to correct versions; however, there can be problems. The pinning models can be incomplete. For example, only top level dependencies are pinned to. Such solutions may be dependent on retrieving pinned dependencies from other third party external resources at deployment. There may be reliance on external resources being available. There may be reliance on a deployment system having or obtaining all the necessary pre-requisites.

SUMMARY OF THE INVENTION

A method, system and computer-usable medium for containerized deployment of microservices is described. One or more microservices are accessed to develop a product or service. Artifacts related to particular versions of the one or more microservices are determined. An immutable container of the artifacts is created and provided to one more environments using the same configuration of the product or service. The container is deployed in the environments during release of the product or service.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention may be better understood, and its numerous objects, features and advantages made apparent to those skilled in the art by referencing the accompanying drawings. The use of the same reference number throughout the several figures designates a like or similar element.

FIG. **1** depicts an example information handling system that can be used to implement the system and method of the present invention;

FIG. **2** depicts a simplified block diagram of an edge device;

FIG. **3** depicts an example containerized microservice infrastructure; and

FIG. **4** is generalized flowchart for providing containerized deployment of microservices.

DETAILED DESCRIPTION

A method, system and computer-usable medium are disclosed for containerized deployment of microservices. In certain implementations, containers or containerized artifacts related to particular versions of microservices or modules of code are provided, such as the same and consistent versions are provided. Such containers and artifacts can be deployed at various stages of a product or service, assuring consistent configuration. Therefore, the same versions can be deployed at the various stages, in different environments, that can include development environment, integration environment, operations environment, and customer environment. When installing, debugging, and troubleshooting take place at any of the environments, there is an assurance that the same configuration has been deployed at the other environments. In other words, it is assured that the same modules and code are being used and have not changed from one environment to another. Consistency and repeatability are provided with the containerized deployment of microservices.

For the purposes of this disclosure, a computing device or an information handling system may include any instrumentality or aggregate of instrumentalities operable to compute, classify, process, transmit, receive, retrieve, originate, switch, store, display, manifest, detect, record, reproduce, handle, or utilize any form of information, intelligence, or data for business, scientific, control, entertainment, or other purposes. For example, an information handling system may be a personal computer, a mobile device such as a tablet or smartphone, a consumer electronic device, a connected "smart device," a network appliance, a network storage device, a network gateway device, a server or collection of servers or any other suitable device and may vary in size, shape, performance, functionality, and price. The information handling system may include volatile and/or non-volatile memory, and one or more processing resources such as a central processing unit (CPU) or hardware or software control logic. Additional components of the information handling system may include one or more storage systems, one or more wired or wireless interfaces for communicating with other networked devices, external devices, and various input and output (I/O) devices, such as a keyboard, a mouse, a microphone, speakers, a track pad, a touchscreen and a display device (including a touch sensitive display device). The information handling system may also include one or more buses operable to transmit communication between the various hardware components.

For the purposes of this disclosure, computer-readable media may include any instrumentality or aggregation of instrumentalities that may retain data and/or instructions for a period of time. Computer-readable media may include, without limitation, storage media such as a direct access storage device (e.g., a hard disk drive or solid state drive), a sequential access storage device (e.g., a tape disk drive),

optical storage device, random access memory (RAM), read-only memory (ROM), electrically erasable programmable read-only memory (EEPROM), and/or flash memory; as well as communications media such as wires, optical fibers, microwaves, radio waves, and other electromagnetic and/or optical carriers; and/or any combination of the foregoing.

FIG. **1** is a generalized illustration of an information handling system **100** that can be used to implement the system and method of the present invention. The information handling system **100** includes a processor (e.g., central processor unit or "CPU") **102**, input/output (I/O) devices **104**, such as a display, a keyboard, a mouse, and associated controllers, a storage system **106**, and various other subsystems **108**. In various embodiments, the information handling system **100** also includes network port **110** operable to connect to a network **140**, which is likewise accessible by a service provider server **142**. The information handling system **100** likewise includes system memory **112**, which is interconnected to the foregoing via one or more buses **114**. System memory **112** further includes operating system (OS) **116** and in various embodiments may also include a security analytics system **118**. In one embodiment, the information handling system **100** is able to download the security analytics system **118** from the service provider server **142**. In another embodiment, the security analytics system **118** is provided as a cloud service from the service provider server **142**.

In various embodiments, the security analytics system **118** performs a security analytics operation. In certain embodiments, the security analytics operation improves processor efficiency, and thus the efficiency of the information handling system **100**, by facilitating security analytics functions. As will be appreciated, once the information handling system **100** is configured to perform the security analytics operation, the information handling system **100** becomes a specialized computing device specifically configured to perform the security analytics operation and is not a general-purpose computing device. Moreover, the implementation of the security analytics system **118** on the information handling system **100** improves the functionality of the information handling system **100** and provides a useful and concrete result of performing security analytics functions to mitigate security risk. In certain embodiments, the security analytics system **118** may be implemented to include a containerized microservices infrastructure **120**. In certain embodiments, the containerized microservices infrastructure **120** perform various microservice operations, such as in the form of software applications, described in greater detail herein. As described herein, the containerized microservices infrastructure **120** includes immutable or unchanging deployment artifacts which provides for a repeatable and consistent configuration to be used at various stages of the product or service, where the product or service is a software application. The repeatable and consistent configuration is used for different environments, such as development, integration, operations, and customer.

FIG. **2** is a simplified block diagram of an edge device implemented in accordance with an embodiment of the invention. As used herein, an edge device, such as the edge device **202** shown in FIG. **2**, broadly refers to a device providing an entry point or gateway into a network **140**. Examples of such edge devices **202** may include routers, routing switches, integrated access devices (IADs), multiplexers, wide-area network (WAN) access devices, and network security appliances, and a cybersecurity system or part of a cybersecurity system. In certain embodiments, the network **140** may be a private network (e.g., an enterprise network), a semi-public network (e.g., a service provider core network), or a public network (e.g., the Internet).

Skilled practitioners of the art will be aware that edge devices **202** are often implemented as routers that provide authenticated access to faster, more efficient backbone and core networks. Furthermore, current industry trends include making edge devices **202** more intelligent, which allows core devices to operate at higher speed as they are not burdened with additional administrative overhead. Accordingly, such edge devices **202** often include Quality of Service (QoS) and multi-service functions to manage different types of traffic. Consequently, it is common to design core networks with switches that use routing protocols such as Open Shortest Path First (OSPF) or Multiprotocol Label Switching (MPLS) for reliability and scalability. Such approaches allow edge devices **202** to have redundant links to the core network, which not only provides improved reliability, but enables enhanced, flexible, and scalable security capabilities as well.

In certain embodiments, the edge device **202** may be implemented to include a communications/services architecture **204**, various pluggable capabilities **206**, a traffic router **208**, and a pluggable hosting framework **210**. In certain embodiments, the communications/services architecture **204** may be implemented to provide access to and from various networks **140**, cloud services **212**, or a combination thereof. In certain embodiments, the cloud services **212** may be provided by a cloud infrastructure familiar to those of skill in the art. In certain embodiments, the edge device **202** may be implemented to provide support for a variety of generic services, such as directory integration, logging interfaces, update services, and bidirectional risk/context flows associated with various analytics. In certain embodiments, the edge device **202** may be implemented to provide temporal information, described in greater detail herein, associated with the provision of such services.

In certain embodiments, the edge device **202** may be implemented as a generic device configured to host various network communications, data processing, and security management capabilities. In certain embodiments, the pluggable hosting framework **210** may be implemented to host such capabilities in the form of pluggable capabilities **206**. In certain embodiments, the pluggable capabilities **206** may include capability '1' **214** (e.g., basic firewall), capability '2' **216** (e.g., general web protection), capability '3' **218** (e.g., data sanitization), and so forth through capability 'n' **220**, which may include capabilities needed for a particular operation, process, or requirement on an as-needed basis. In certain embodiments, such capabilities may include the performance of operations associated with the containerized microservices infrastructure **120**.

In certain embodiments, the pluggable capabilities **206** may be sourced from various cloud services **212**. In certain embodiments, the pluggable hosting framework **210** may be implemented to provide certain computing and communication infrastructure components, and foundation capabilities, required by one or more of the pluggable capabilities **206** In certain embodiments, the pluggable hosting framework **210** may be implemented to allow the pluggable capabilities **206** to be dynamically invoked. Skilled practitioners of the art will recognize that many such embodiments are possible. Accordingly, the foregoing is not intended to limit the spirit, scope or intent of the invention.

In certain implementations, an administrator(s) **222**, such as a software application developer(s) connects with the network **140** through an administrative system represented

by administrative server **224**. Administrator **222** can control or have responsibility for one more containerized microservice infrastructure(s) **120** which can be stored in a data store **226**. In particular, the one more containerized microservice infrastructure(s) **120** can be archived and made available to different information handling systems, such as edge device **202**.

Various microservices, may be available at various locations, including websites, data repositories, etc. In certain implementations, microservices can be provided through cloud services, such as cloud services **212**. Microservices can provide a software development technique, which is a variant of a service-oriented architecture (SOA) structural style, arranging an application, such as a software application developed as a product or service, as a collection of loosely coupled services. The use of open source modules can be implemented as part of such microservices. Microservice **1 226-1**, microservice **2 226-2** to microservice N **226**-N represented such microservices and are accessible through network **140**.

FIG. **3** is an example of a containerized microservice infrastructure. As discussed herein, the containerized microservice infrastructure **120** is immutable or unchanging, assuring repeatable and consistent configurations for various environments and stages. Therefore, the same and consistent versions of modules or code can be provided for other releases, assisting in deployment and debugging.

In certain implementations, a platform as a service or PaaS, such as Docker can be implemented, where PaaS is a method used by a provider, such as administrator **220** of FIG. **2** to deliver deployment and management capabilities to the end user. A container is a solution to provide such to the end user. Such container technologies are immune to external dependency changes. In certain implementations, the container is implemented as a Node Package Manager or NPM package, as part of an NPM package manager used for JavaScript programming language.

The container or deployment package as represented by containerized microservice infrastructure **120** is used for deployment code and is ran at during release of a product or service assuring the correct version or copy. In an implementation, the containerized microservice infrastructure **120** is called during deployment or implementation of a product or service on an environment (i.e., information handling system).

The containerized microservice infrastructure **120** and its contents, including artifacts can be stored at various locations, including the data store **226** and websites/sites, and shared/stored at other locations, including portable storage devices, such as USB drives.

In certain embodiments, the containerized microservice infrastructure **120** includes a deployment tool **302**, used for deploying code during release. One or more artifacts as represented by artifact **304** is/are included as part of a container or containerized microservice infrastructure **120**. The artifact(s) **304** in the containerized microservice infrastructure **120** (container/deployment package) is/are immutable or never change.

In certain embodiments, the artifact(s) **304** includes code to deploy microservice(s)/service(s) **306**, microservice(s)/service(s) calls **308**, dependencies **310**, tests for code **312**, and references/versions **314**. as to the artifact(s) **304**.

FIG. **4** is generalized process flow **400** for containerized deployment of microservices. The order in which the process flow is described is not intended to be construed as a limitation, and any number of the described blocks can be combined in any order to implement the process flow. Additionally, individual blocks may be deleted from the process flow without departing from the spirit and scope of the subject matter described herein. Furthermore, the process flow may be implemented in any suitable hardware, software, firmware, or a combination thereof, without departing from the scope of the invention.

At block **402**, the process **400** starts. At step **404**, one or more microservices are accessed in order to develop a product or service, such as software application. The product or service is used on an information handling system, such as an edge device describe herein. The one or more microservices as accessed at various locations, including websites, data depositories and cloud services.

At step **406**, a determination is made as to the artifacts of the microservices. In particular, the artifacts are related to certain versions and can include code to deploy microservice(s)/service(s), microservice(s)/service(s) calls, dependencies, tests for code, etc. The artifacts are immutable or do not change.

At step **408**, a container of the artifacts is created. The container is immutable and does not change. The container is specific to a particular configuration. As described herein, the container can be implemented through a platform as a service or PaaS and implemented as an NPM package.

At step **410**, the container is deployed to one or more environments. As discussed herein, the same configuration is used for different environments, such as environments at various stages of the product or service. The container can be provided from various locations, including a developer/administrator controlled data store.

At step **412**, deployment of the container is performed at the one or more environments. As discussed herein, the deployment of the container takes place during deployment of the product or service. As further discussed, the container includes a deployment tool and all the necessary resources to run the deployments, as included in the artifacts, such as deploy microservice(s)/service(s), microservice(s)/service(s) calls, dependencies, tests for code, etc. At block **414**, the process **400** ends.

As will be appreciated by one skilled in the art, the present invention may be embodied as a method, system, or computer program product. Accordingly, embodiments of the invention may be implemented entirely in hardware, entirely in software (including firmware, resident software, microcode, etc.) or in an embodiment combining software and hardware. These various embodiments may all generally be referred to herein as a "circuit," "module," or "system." Furthermore, the present invention may take the form of a computer program product on a computer-usable storage medium having computer-usable program code embodied in the medium.

Any suitable computer usable or computer readable medium may be utilized. The computer-usable or computer-readable medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device. More specific examples (a non-exhaustive list) of the computer-readable medium would include the following: a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), a portable compact disc read-only memory (CD-ROM), an optical storage device, or a magnetic storage device. In the context of this document, a computer-usable or computer-readable medium may be any medium that can contain, store, communicate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

Computer program code for carrying out operations of the present invention may be written in an object oriented programming language such as Java, Smalltalk, C++ or the like. However, the computer program code for carrying out operations of the present invention may also be written in conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the user's computer, partly on the user's computer, as a stand-alone software package, partly on the user's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the user's computer through a local area network (LAN) or a wide area network (WAN), or the connection may be made to an external computer (for example, through the Internet using an Internet Service Provider).

Embodiments of the invention are described with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

These computer program instructions may also be stored in a computer-readable memory that can direct a computer or other programmable data processing apparatus to function in a particular manner, such that the instructions stored in the computer-readable memory produce an article of manufacture including instruction means which implement the function/act specified in the flowchart and/or block diagram block or blocks.

The computer program instructions may also be loaded onto a computer or other programmable data processing apparatus to cause a series of operational steps to be performed on the computer or other programmable apparatus to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide steps for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

The flowchart and block diagrams in the Figures illustrate the architecture, functionality, and operation of possible implementations of systems, methods and computer program products according to various embodiments of the present invention. In this regard, each block in the flowchart or block diagrams may represent a module, segment, or portion of code, which comprises one or more executable instructions for implementing the specified logical function(s). It should also be noted that, in some alternative implementations, the functions noted in the block may occur out of the order noted in the figures. For example, two blocks shown in succession may, in fact, be executed substantially concurrently, or the blocks may sometimes be executed in the reverse order, depending upon the functionality involved. It will also be noted that each block of the block diagrams and/or flowchart illustration, and combinations of blocks in the block diagrams and/or flowchart illustration, can be implemented by special purpose hardware-based systems that perform the specified functions or acts, or combinations of special purpose hardware and computer instructions.

While particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that, based upon the teachings herein, changes and modifications may be made without departing from this invention and its broader aspects. Therefore, the appended claims are to encompass within their scope all such changes and modifications as are within the true spirit and scope of this invention. Furthermore, it is to be understood that the invention is solely defined by the appended claims. It will be understood by those with skill in the art that if a specific number of an introduced claim element is intended, such intent will be explicitly recited in the claim, and in the absence of such recitation no such limitation is present. For non-limiting example, as an aid to understanding, the following appended claims contain usage of the introductory phrases "at least one" and "one or more" to introduce claim elements. However, the use of such phrases should not be construed to imply that the introduction of a claim element by the indefinite articles "a" or "an" limits any particular claim containing such introduced claim element to inventions containing only one such element, even when the same claim includes the introductory phrases "one or more" or "at least one" and indefinite articles such as "a" or "an"; the same holds true for the use in the claims of definite articles.

The present invention is well adapted to attain the advantages mentioned as well as others inherent therein. While the present invention has been depicted, described, and is defined by reference to particular embodiments of the invention, such references do not imply a limitation on the invention, and no such limitation is to be inferred. The invention is capable of considerable modification, alteration, and equivalents in form and function, as will occur to those ordinarily skilled in the pertinent arts. The depicted and described embodiments are examples only and are not exhaustive of the scope of the invention.

Consequently, the invention is intended to be limited only by the spirit and scope of the appended claims, giving full cognizance to equivalents in all respects.

What is claimed is:

1. A computer-implementable method for containerized deployment of microservices comprising:

determining artifacts related to particular versions of the one or more microservices; wherein the artifacts are related to particular versions of code and include one or more of the particular versions of code to deploy the microservices, microservice calls, dependencies, and tests for code;

creating an immutable container of the artifacts that includes a deployment tool;

providing the immutable container to one or more environments using the same configuration of the product or service;

deploying the immutable container at the one or more environments.

2. The method of claim **1**, wherein immutable container is implemented through a Platform as a Service.

3. The method of claim **1**, wherein the immutable container is implemented as Node Package Manager package.

4. The method of claim **1**, wherein the providing the immutable container is performed at various stages of the product or service.

5. The method of claim 1, wherein the deploying the immutable container is performed when the product or service is released.

6. The method of claim 1, wherein the deploying of the immutable container is performed using a deployment tool included in the immutable container at release of the product or service.

7. A system comprising:

a processor;

a data bus coupled to the processor; and

a non-transitory, computer-readable storage medium embodying computer program code, the non-transitory, computer-readable storage medium being coupled to the data bus, the computer program code interacting with a plurality of computer operations and comprising instructions executable by the processor and configured for:

determining artifacts related to particular versions of the one or more microservices, wherein the artifacts are related to particular versions of code and include one or more of the particular versions of code to deploy the microservices, microservice calls, dependencies, and tests for code;

creating an immutable container of the artifacts that includes a deployment tool;

providing the immutable container to one or more environments using the same configuration of the product or service;

deploying the immutable container at the one or more environments.

8. The system of claim 7, wherein immutable container is implemented through a Platform as a Service.

9. The system of claim 7 wherein the immutable container is implemented as Node Package Manager package.

10. The system of claim 7, wherein the providing the immutable container is performed at various stages of the product or service.

11. The system of claim 7, wherein the deploying the immutable container is performed when the product or service is released.

12. The system of claim 7, wherein deploying of the immutable container is performed using a deployment tool included in the immutable container at release of the product or service.

13. A non-transitory, computer-readable storage medium embodying computer program code, the computer program code comprising computer executable instructions configured for:

accessing one or more microservices are accessed to develop a product or service;

determining artifacts related to particular versions of the one or more microservices, wherein the artifacts are related to particular versions of code and include one or more of the particular versions of code to deploy the microservices, microservice calls, dependencies, and tests for code;

creating an immutable container of the artifacts that includes a deployment tool;

providing the immutable container to one or more environments using the same configuration of the product or service;

deployment the immutable container at the one or more environments.

14. The non-transitory, computer-readable storage medium of claim 13, wherein immutable container is implemented through a Platform as a Service.

15. The non-transitory, computer-readable storage medium of claim 13, wherein the providing the immutable container is performed at various stages of the product or service.

16. The non-transitory, computer-readable storage medium of claim 13, wherein the deploying the immutable container is performed when the product or service is released.

17. The non-transitory, computer-readable storage medium of claim 13, wherein the deploying of the immutable container is performed using a deployment tool included in the immutable container at release of the product or service.

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